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PERFORMANCE OF THE SLD CENTRAL DRIFT CHAMBER PROTOTYPE*

C.C. YOUNG, W.B. ATWOOD, J. CARR, G. CHADWICK, S. CSORNA, T. HANSL-KOZANECKA, C.L. HODGES, G. MUNDY, U. NAUENBERG, R. PANVINI, C.Y. PRESCOTT, T.W. REEVES, L.S. ROCHESTER, S. SALOMON, K. SIMPSON, AND A. STEINER

San Francisco State University, San Francisco, California 94132
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305
University of Colorado, Boulder, Colorado 80309
Vanderbilt University, Nashville, Tennessee 37235

Abstract

A two-cell prototype of the SLD Central Drift Chamber has been tested using CO_2-isobutane (92%-8%) at one atmosphere. Average single wire resolution of 55 μm was achieved. Charge division tests indicate a resolution for the final design of $\approx 0.5\%$ of wire length. dE/dx separation of $\pi - e$ should be useful up to at least 7 GeV/c.

Introduction

The Central Drift Chamber (CDC) is the main charged particle tracking device in the SLD detector.[1] It will consist of 10 cylindrical superlayers, 4 axial and 6 at small stereo angles. Each layer is divided azimuthally into cells approximately 6 cm wide. As shown in Fig. 1, each cell has 8 sense wires, which are separated from one another by two guard wires. Thus, an outward going track will have 80 measurements.

A gas mixture of 92% CO_2 with 8% isobutane at atmospheric pressure has been tested. The cell design provided a uniform drift field of $\approx$ 1 kV/cm, and a drift velocity of 9 μm/nsec. In the high field region around the sense wires, the drift velocity was correspondingly higher. Gas gain was $\approx 10^5$.

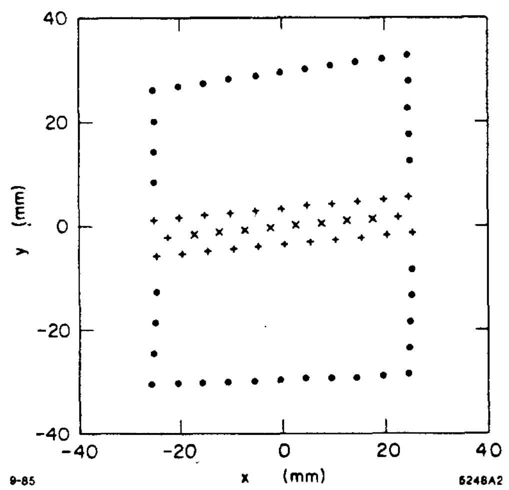

Fig. 1. The prototype drift chamber cell. Sense wires are shown as $\times$. Guard wires are shown as $+$, and field wires as $\cdot$. Two such cells were instrumented, and partial cells surrounding them help establish the proper electrostatic configuration.

Experimental Setup

The prototype had two full-size non-stereo cells in x and y, but was only 80 cm long. Extra partial cells were included to obtain a realistic field configuration, but were not instrumented. The prototype was placed in a test beam, and a uniform magnetic field of up to 10 kgauss was applied along the wire direction.

Ten of the sense wires were tungsten, while the others were stainless steel. The wire resistances were 150 Ω and 1250 Ω respectively. Preamplifiers with input impedances of 30 Ω (Laben 5242) were mounted on both ends of each sense wire. Pulse heights were digitized by LeCroy 2249W ADC's, and drift times were measured using LeCroy 2228A TDC's with a 2.5 nsec least count. The pulse height threshold used in timing measurements corresponded to 1/3 of an incoming electron. Each wire saw $\approx$ 16 primary ionization clusters.

The CDC prototype was situated between two sets of four proportional wire chambers (PWC), which provided an external tracking reference along the drift direction as well as along the wire length.

The beam line was equipped with a hydrogen gas Čerenkov counter. Its pressure was set to distinguish electrons from heavier particles. A lead-scintillator shower counter was placed downstream of the CDC prototype to provide additional discrimination between electrons and other particles.

The data reported here were taken with an average of 0.2 beam particles per pulse in order to minimize multi-track events. Further cuts were applied during the analysis to reject multi-track events.

Drift Resolution

Track positions reconstructed from the PWC system were plotted against measured drift times to obtain empirical time-to-distance relationships for each of the 16 sense wires. The measured drift times could then be converted to drift distances, and tracks were then fitted using the drift chamber hits only. The residual between the fitted track and each of the measurements determines the drift resolution.

Figure 2 shows the single wire drift resolution as a function of drift distance. An average resolution over the cell of 55 μm was achieved. The resolution expected from a computer simulation[2] of this drift cell and gas is shown by the smooth curve. The agreement is excellent except for the largest drift distances, and shows that the resolution is close to the predicted diffusion limit.

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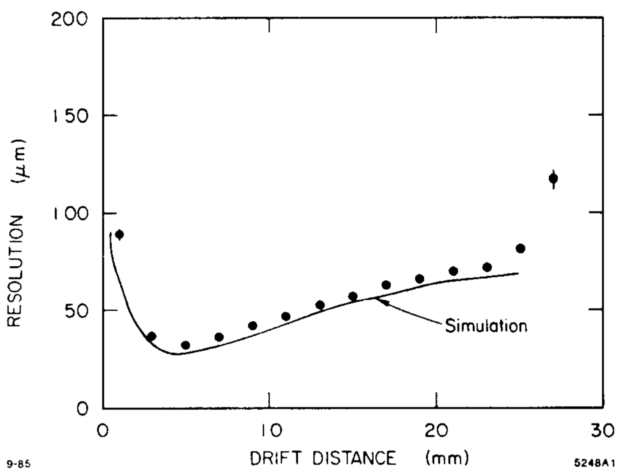

Fig. 2. Drift resolution *vs* drift distance. The average resolution over the 29-mm drift space is 55 μm. The smooth curve is the prediction of a computer simulation of this drift cell and gas.

Charge Division Resolution

The hit position along the wire obtained through charge division was plotted against the position given by the PWC, and a Gaussian fit was used to obtain the charge division resolution. In the case of tungsten sense wires, a resolution of 8.4 mm (1.1% of wire length) was obtained. A resolution of 3.1 mm (0.40% of wire length) was achieved in the case of stainless steel sense wires. The PWC-tracking resolution of approximately 0.2 mm contributed negligibly to these results.

Charge division resolution is plotted as a function of the inverse of the total charge in Fig. 3, showing an improved resolution for higher pulse heights. The relative performance of tungsten and stainless steel sense wires indicates that the resolution is limited by the Johnson noise of the wires. These results indicate that a charge division resolution of $\approx 0.5\%$ of wire length can be achieved in the 180-cm long CDC using the stronger tungsten sense wires. Higher resistance stainless steel wire is not needed.

dE/dx

The CDC design is optimized for tracking, while particle identification in the SLD will depend on Čerenkov Ring Imaging Detectors. However, further π/e separation by dE/dx in the CDC is possible, and has been studied. Electrons in the beam were identified by requiring a signal from the Čerenkov counter and a large pulse height in the shower counter. Pions were identified by the absence of these signals.

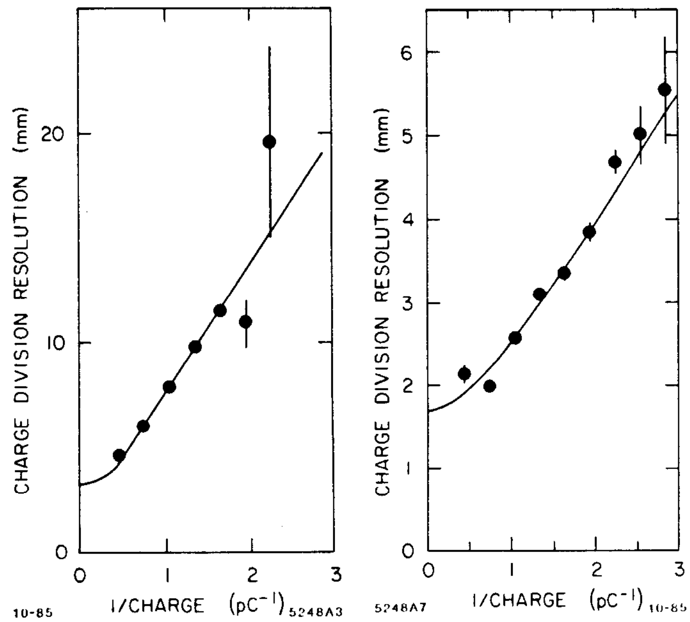

Fig. 3. Charge division resolution *vs* total charge for (a) tungsten and (b) stainless steel sense wires. Resolution limited by thermal noise is linear in 1/charge. The smooth curves show that other contributions to the resolutions are small in comparison to thermal noise.

To simulate the final CDC, where 80 hits per track are possible, 5 tracks in the prototype, each having 16 dE/dx samples, were combined into one "track". The average pulse height was computed using a truncated mean method. The 64 samples (out of 80) with the smallest pulse heights were used. Table I summarizes the results on π/e separation and shows a comparison with theoretical calculations.[3]

Possible saturation effects in gas gain were studied by varying the high voltages. No change in π/e separation was found for gas gains down to 1/5 of nominal.

Table I

	π/e Separation	
Momentum (GeV/c)	Measured	Calculated
4	2.2 σ	3.1 σ
7	1.6 σ	2.0 σ
11	1.2 σ	1.2 σ

References

1. SLD Design Report, SLAC Report 273, May 1984.
2. J. Va'Vra and L. Roberts, *DRIFT* Program, SLAC, 1982.
3. Private communication from W.W.M. Allison, Department of Nuclear Physics, Oxford University, Oxford, U.K.